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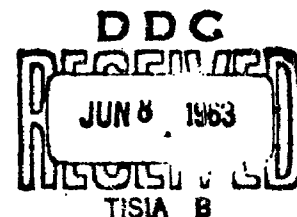
**BRL**

**405 889**

MEMORANDUM REPORT NO. 1464  
APRIL 1963

**A SECOND TEST OF AN  
UPPER ATMOSPHERE GUN PROBE SYSTEM**

Spence T. Marks  
Eugene D. Boyer



RDT & E Project Nos. 1A011001B021 and 1M010501A005  
**BALLISTIC RESEARCH LABORATORIES**

**ABERDEEN PROVING GROUND, MARYLAND**

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B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

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A B E R D E E N   P R O V I N G   G R O U N D ,   M A R Y L A N D



FRONTISPIECE - EXTENDED GUN ON CARRIAGE

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

MEMORANDUM REPORT NO. 1464

STMarks/EDBoyer/cet  
Aberdeen Proving Ground, Md.  
April 1963

A SECOND TEST OF AN  
UPPER ATMOSPHERE GUN PROBE SYSTEM

ABSTRACT

The second phase of a high altitude gun probe project is presented. The project objectives, the design considerations, the proof tests, the vertical tests and the dispersion of the system are discussed. An altitude capability of at least 240,000 ft. and an impact circle requirement of one-mile radius has been demonstrated in two series of firings on the Edgewood peninsula of the Aberdeen Proving Ground. Although the performance of this fin-stabilized, five-inch projectile has been proved, the tests indicate the need for further development of data packages and fuzes.

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## I. INTRODUCTION

While interest in gun fired probes dates back at least half a century, it was not until recently that serious consideration has been given to gun fired probes for making high altitude measurements. Two feasibility studies of high altitude gun probes for the purpose were conducted late in 1959, and early in 1960. One study, conducted at the Canadian Armament Research and Development Establishment, contemplated the use of a spinning probe from a 3.3-inch gun;<sup>1</sup> while a similar study at the Ballistic Research Laboratories resulted in a proposal that a non-spinning probe be employed from a smoothbore 5-inch gun.<sup>2</sup>

A feasibility test<sup>3,4,5</sup> of the proposed 5-inch gun probe system was conducted by the BRL at Aberdeen Proving Ground, Maryland, during 1961. A smoothbore T123 tank gun, and probes constructed from T144 projectile parts were used during the test. These probes were lighter and weaker than desired, and their drag was high. As a result, some of the probes suffered structural failure during the test, and the maximum altitude reached was only 130,000 ft.

The report which described the 1961 feasibility test recommended that an improved 5-inch gun probe system be developed.<sup>5</sup> Such a system would employ a suitable gun with a barrel extension and a heavier probe of greater strength and lower drag.

The present report describes the results obtained from tests of a redesigned 5-inch gun probe system which were conducted by the BRL at Aberdeen Proving Ground during 1962 with the partial support of the Defense Atomic Support Agency under WEB No. 07013.

Design of a 7-inch system is presently in progress. This increased scale will retain the mobility of the 5-inch system but will possess a 300,000-ft. altitude capability with over three times the payload volume. In addition to these developments at the BRL, the Army is supporting development of a 16-inch gun probe system,<sup>6</sup> on the island of Barbados, W. I. F., under contract with the McGill University of Montreal, Canada. Although this size of gun clearly lacks the mobility of the smaller gun, it can put payloads of 300 lbs. to altitudes in excess of 300,000 ft. For seeding experiments,<sup>7</sup> this approach is economically very attractive.

## II. PROJECT OBJECTIVES

### A. Primary

The primary objective of the gun probe project during 1962 was the development of an advanced 5-inch gun probe system with an altitude capability of 200,000 - 250,000 ft.

This objective was to be accomplished by fitting a suitable gun with a barrel extension and designing a heavier probe of greater strength and lower drag for use with the gun.

The altitude capability of the system was to be determined by employing the elapsed time of flight method,<sup>8</sup> and such other altitude determination methods as could be devised for the purpose.

### B. Secondary

The secondary objective of the gun probe project during 1962 was the continued development of payload packages for use with the gun probe system.

This work was to include: (1) additional development and testing of inert packages, examples being chaff and artificial meteor experiments, and (2) a beginning on the development and testing of active packages, an example being a telemetry package for high altitude temperature measurements.

## III. DESIGN CONSIDERATIONS

### A. Gun and Probe

The principal parameters which determine the capability of a gun system to propel a probe to a given altitude are (1) the muzzle velocity, and (2) the ballistic properties of the probe.<sup>2</sup> The parameter  $\frac{W}{C_{D_0} A}$  has been adopted to represent the latter. To establish performance requirements, the equation

$$z = \left( \frac{\rho V^2}{2} \right) \left( \frac{C_{D_0} A}{W} \right) - g$$

was integrated on a digital computer, where  $z$  = height (ft),  $g$  = acceleration of gravity (ft/sec<sup>2</sup>),  $\rho$  = air density (lb/ft<sup>3</sup>),  $V$  = velocity (ft/sec),  $C_{D_0}$  = zero-yaw drag coefficient,  $A$  = cross sectional area (ft<sup>2</sup>), and  $W$  = weight (lb).

In performing the integration the variation of  $C_{D_0}$  with Mach number was taken into account,\* gravity was constant, and the standard ballistic variation of density with altitude was assumed. The results are given in Fig. 1.

The chaff probe tested in 1961 was fired from a 24-foot gun tube and at most attained a muzzle velocity of 5250 ft/sec.  $C_{D_0}$  was about 0.30 at Mach 4.4. This drag with a 16.6-pound probe gave a  $\frac{W}{C_{D_0} A}$  value of 1900 lb/ft<sup>2</sup>. Thus, reference to Fig. 1 shows that this probe only had the capability to reach an altitude of 130,000 ft.

The solution to the problem of redesigning the 5-inch gun probe system to reach an altitude of 200,000 ft. or higher required an increase in the muzzle velocity of the probe and an increase in its  $W/C_{D_0} A$  value (Fig. 1).

It was estimated that a barrel extension of 20 calibers would provide an additional 300 ft/sec muzzle velocity, and hence, a 10-ft. extension was added to the T123 tank gun for the 1962 test (Frontispiece).

The weight of the probe was increased from 16.6 lbs. to approximately 19.5 lbs. for the 1962 test, and more streamlined nose and fin units were employed to reduce drag (Figs. 2 and 3).

The increased weight of the probe, of course, required that more powder be employed to propel the probe, with a resultant increase of the erosion effect in the gun. This effect was off-set to a considerable extent by employing a colder powder and an improved primer.

With improved muzzle velocities up to 5500 ft/sec and an increased  $W/C_{D_0} A$  as large as 3100 lb/ft<sup>2</sup> (depending upon the package carried) reference to Fig. 1 indicated that the redesigned probe should easily reach the desired 200,000 ft. altitude and indeed exceed it by as much as 50,000 ft.

#### B. Payload Packages

The payload compartment of the redesigned gun probe was located in the forward body of the probe (Fig. 3). This compartment measured 6.5" in length by 1.8" in diameter with a total volume of 16.5 cubic inches.

\* The Mach number variation used is that shown in Fig. 9.

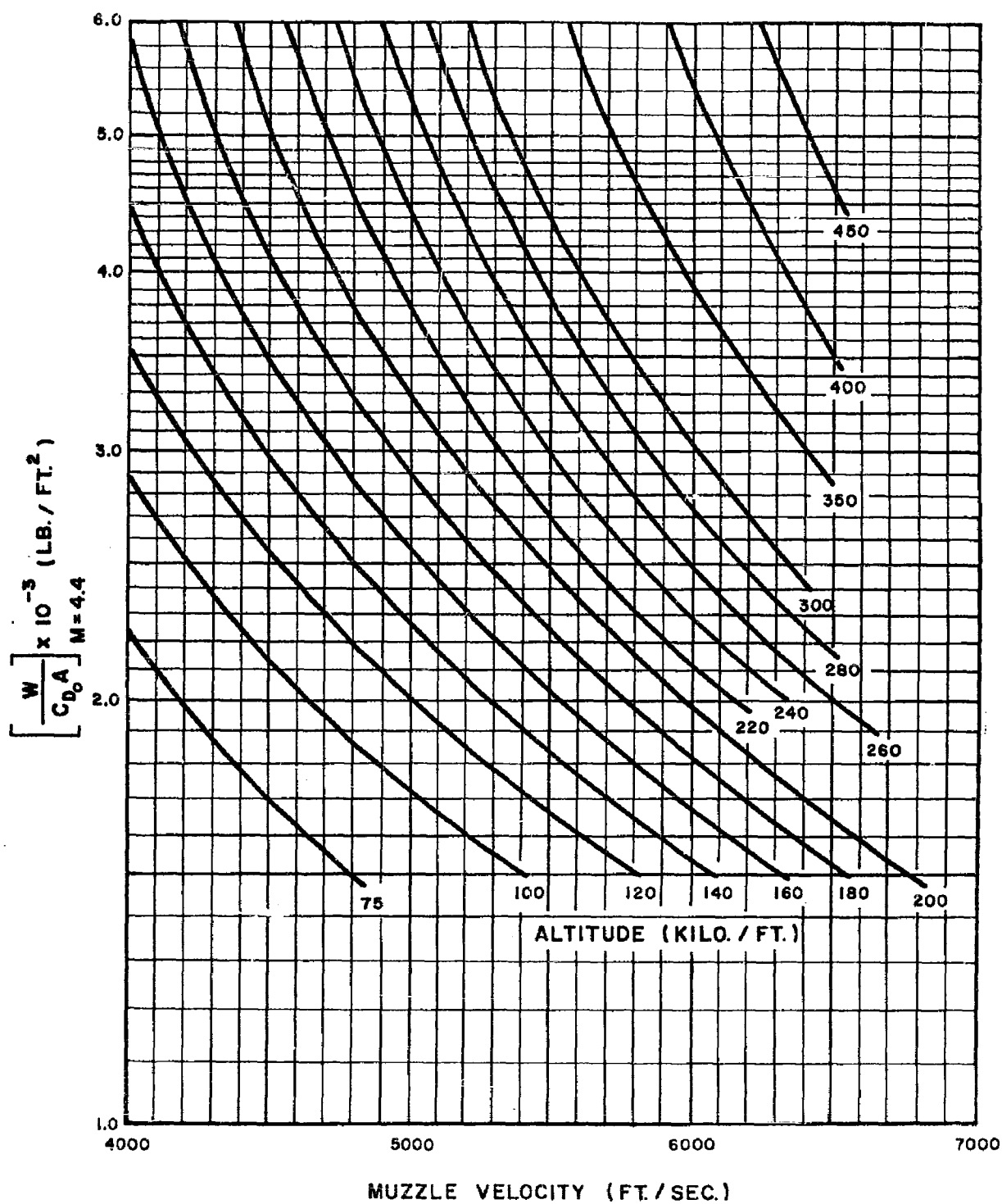


FIG. 1 - ALTITUDE PROFILES AS A FUNCTION OF BALLISTIC COEFFICIENT AND MUZZLE VELOCITY

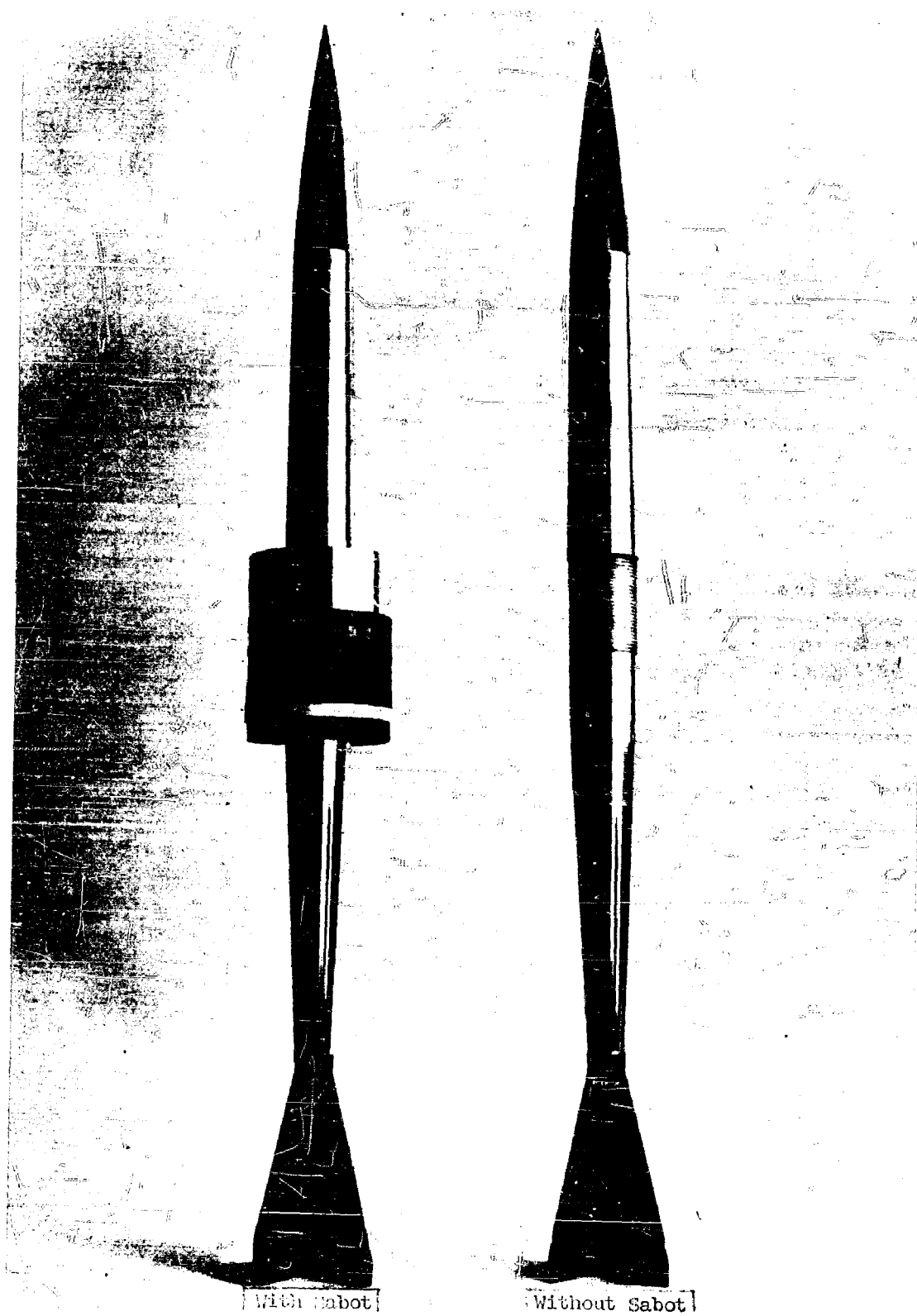
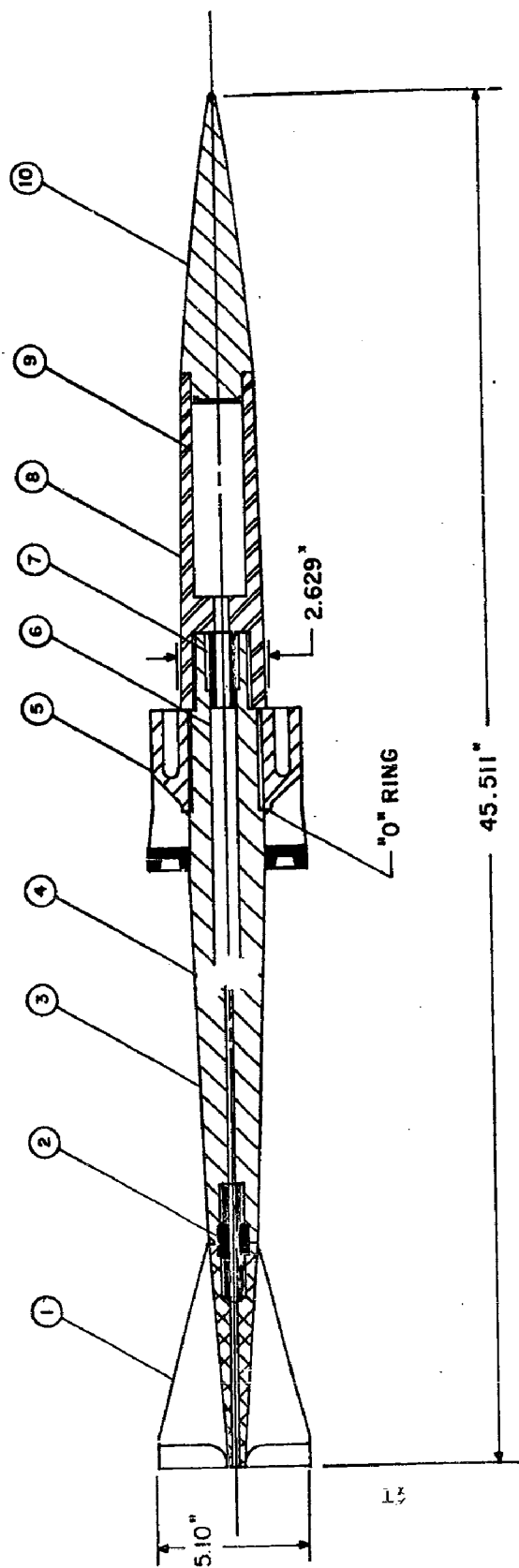


FIG. 2 PHOTOGRAPH OF SECOND GENERATION GUN PROBE



- |               |                     |
|---------------|---------------------|
| 1 - FIN       | 6 - EJECTION FUZE   |
| 2 - TAIL STUD | 7 - EJECTION CHARGE |
| 3 - TAIL BOOM | 8 - FORWARD BODY    |
| 4 - TAIL VENT | 9 - PAYLOAD         |
| 5 - SABOT     | 10 - NOSE SECTION   |

FIG. 3 - SECTIONAL VIEW OF SECOND GENERATION GUN PROBE



FIG. 4 PHOTOGRAPH OF NEW EJECTION FUZE



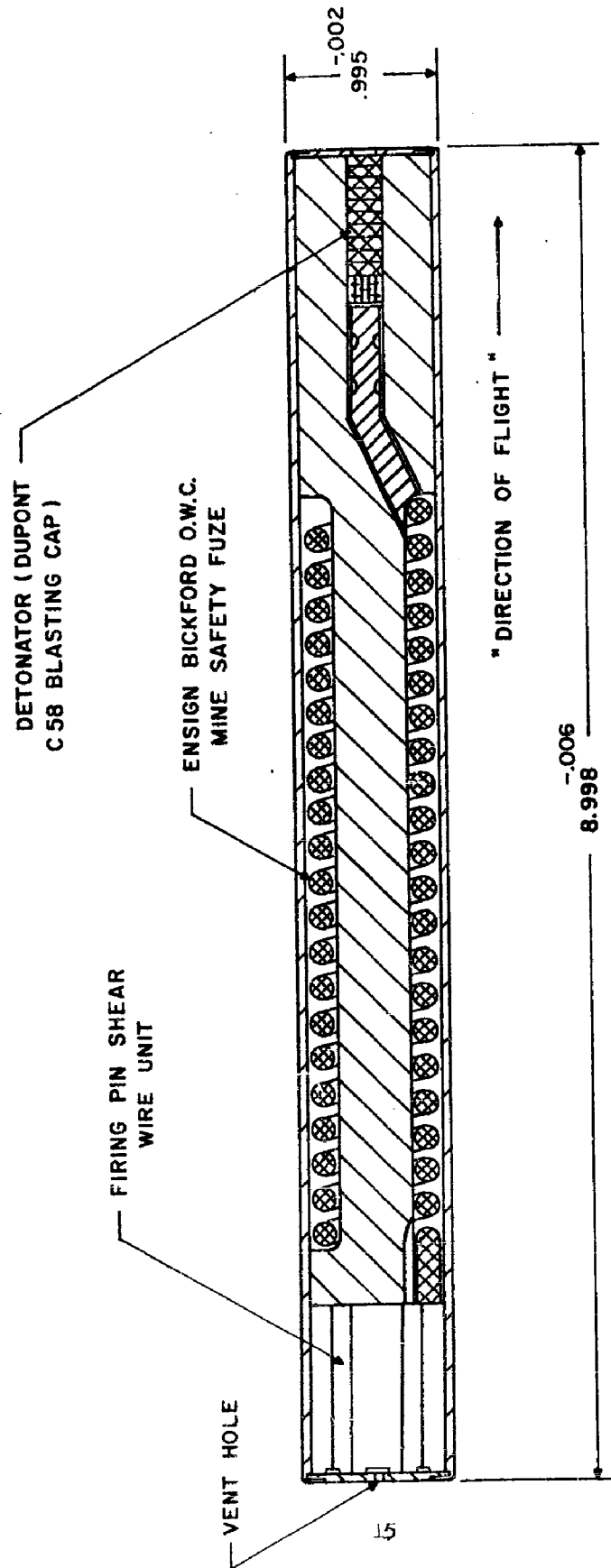


FIG. 5 - SECTIONAL VIEW OF NEW EJECTION FUZE

The ejection fuze was moved from the rear of the payload compartment to a location in the forward part of the tailboom (Fig. 3). This change required a repackaging of the pyrotechnic fuze\* which had functioned satisfactorily during the 1961 tests. The original fuze was short and thick (2.15" by 1.8" diameter) while the new design was required to be long and thin (9" by 1" diameter). Except for this change, it was expected that the two fuzes would be the same in material and principle of operation. One feature did appear to be more critical than that of the earlier model; the new design required the coiling of the fuze cord at minimum radius, and there was a question as to whether this could be done without damaging the powder train. However, tests by the manufacturer\*\* indicated that the fuze cord could be ignited and would burn reliably after the tight winding. Initially, the new design employed the starters used in the 1961 fuze, but following some failures these units were replaced by a firing pin shear wire arrangement designed to function on a launch setback of 20,000 g's. The fuze terminated in a DuPont C58 blasting cap (Figs. 4 and 5).

No change was made in the chaff package for the 1962 test, it being essentially the same as the chaff package which was successfully ejected and tracked at 100,000 ft. during the 1961 test. It was desired, however, to secure more experimental data with this package by ejecting and tracking it at an altitude of 200,000 ft.

The chaff package contained aluminized nylon filaments 1.5 centimeters in length ( $1/2$  wavelength for X-band radar). Only one diameter of chaff was used during the 1962 test, i.e., 0.0035", because it was more suitable for use at the higher altitude. The chaff was enclosed in a steel case (Fig. 6) designed to open upon ejection of the case from the forward end of the probe. Ejection was to be accomplished by igniting a powder charge at the base of the package. Total weight of the chaff and case was 1.8 lbs.

The artificial meteor package for the 1962 test was modified to provide for the ejection of a more visible material to aid in demonstrating experiment feasibility. The same basic configuration was employed for the meteor ejection device as was used previously (Fig. 6); however, a cylindrical liner

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\*Manufactured by Harry Diamond Laboratories  
\*\*Ordnance Products Co., North East, Maryland

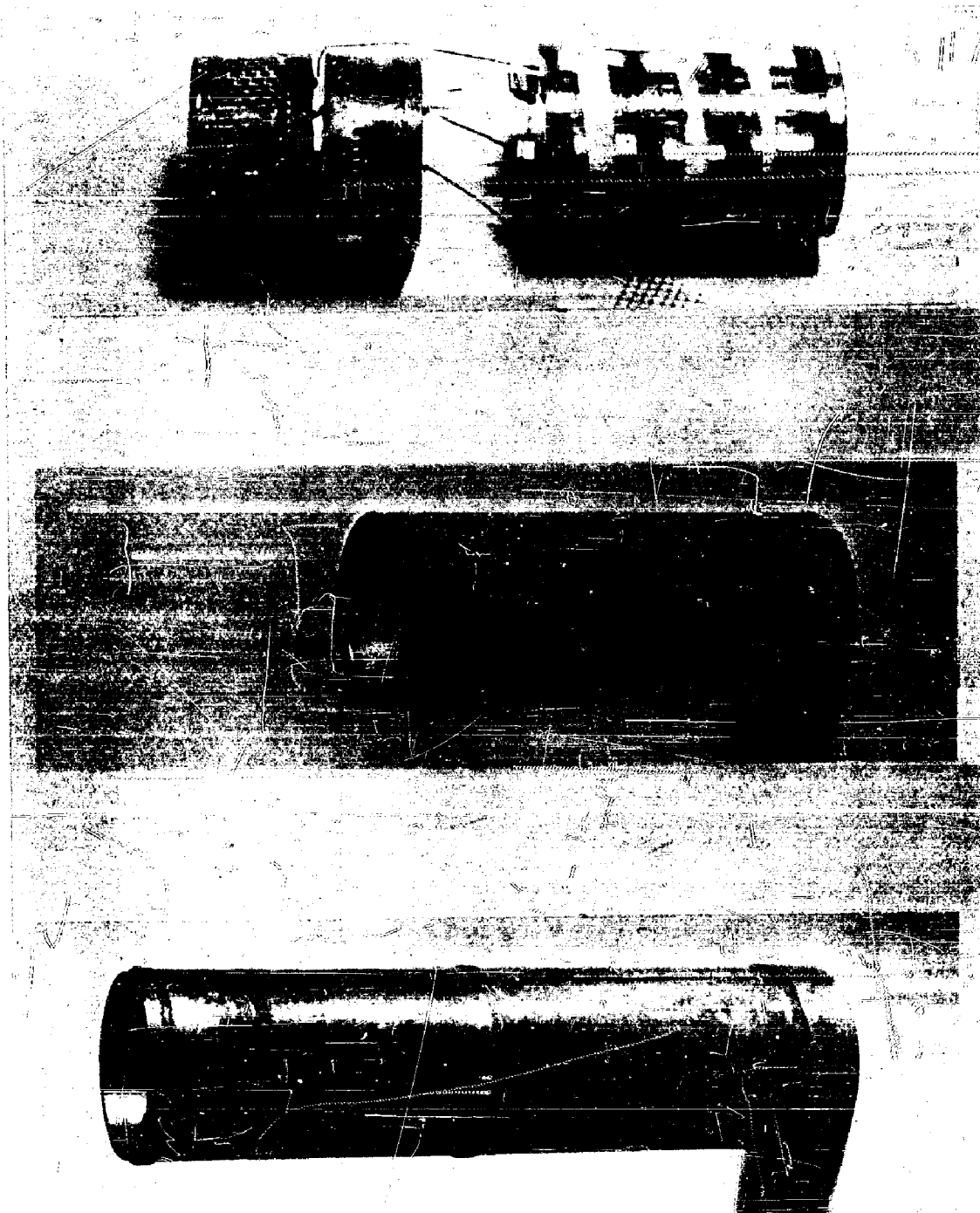


FIG. 6 PHOTOGRAPH OF CHAFF, METEOR AND TELEMETRY PACKAGES

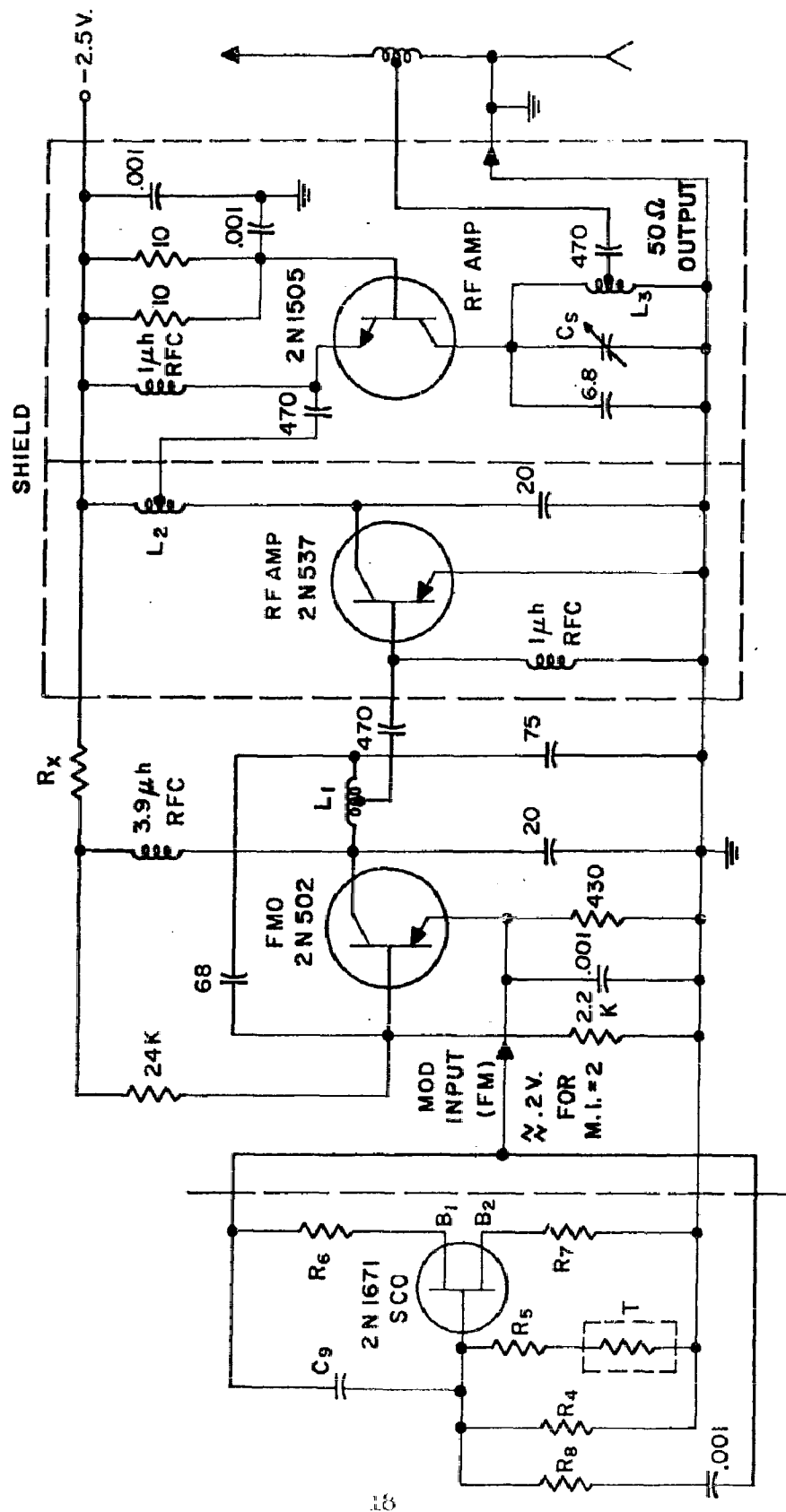


FIG. 7 - CIRCUIT OF TELEMETRY PACKAGE

weighing 1.2 oz. was used with a Baratol charge weighing 1.5 lb. This device, known as the BRL Jet-pellet accelerator,<sup>9</sup> was designed to eject a single 0.01-oz. aluminum pellet, rod-like in shape, from the nose tip of the probe vehicle at a velocity of 26 to 30 kft/sec.

A telemetry package with a radiated output of 20 mw at a frequency of 70 mc was developed by the Harry Diamond Laboratories for the first test of a telemetry unit on the gun probe (Figs. 6 and 7). The telemetry unit was plotted in the forward body of the gun probe for the first test, with the probe body and nose section serving as a dipole antenna. A later test is to be conducted with an ejectable telemetry package/parachute combination.

A flash package\* consisting of 5 ozs. of 60% barium nitrate and 40% aluminum and magnesium powder, contained in an aluminum container, was used in the June 1962 firings for altitude determination purposes. There was some doubt as to the light output of this package at high altitude,<sup>10</sup> and Picatinny Arsenal supplied a new flash unit for the December 1962 firings. The latter unit contained 5 ozs. of 40% aluminum, 30% potassium perchlorate and 30% barium nitrate. This mixture was also carried in an aluminum container with a total weight of 1.3 lbs.

#### IV. PROOF TESTS

##### A. Gun Probe

An extensive series of horizontal firings was conducted as a part of the 1962 test. The program included the firing of ten slugs and ten redesigned gun probes from an extended T123 tank gun.

Unexpected yawing effects were encountered when the first group of redesigned gun probes were fired horizontally, but this difficulty was overcome by modifying the fins of the newly designed probe to provide more riding surface area.

The second generation probe was then fired through the Transonic Range at Aberdeen Proving Ground to obtain drag data, and the mosaic shadowgraph of Fig. 8 was made. The physical and aerodynamic properties of the probe are given in Table I. The test results indicated that the drag coefficient,  $C_{D_0}$ ,

\* built by Development and Proof Services, Aberdeen Proving Ground

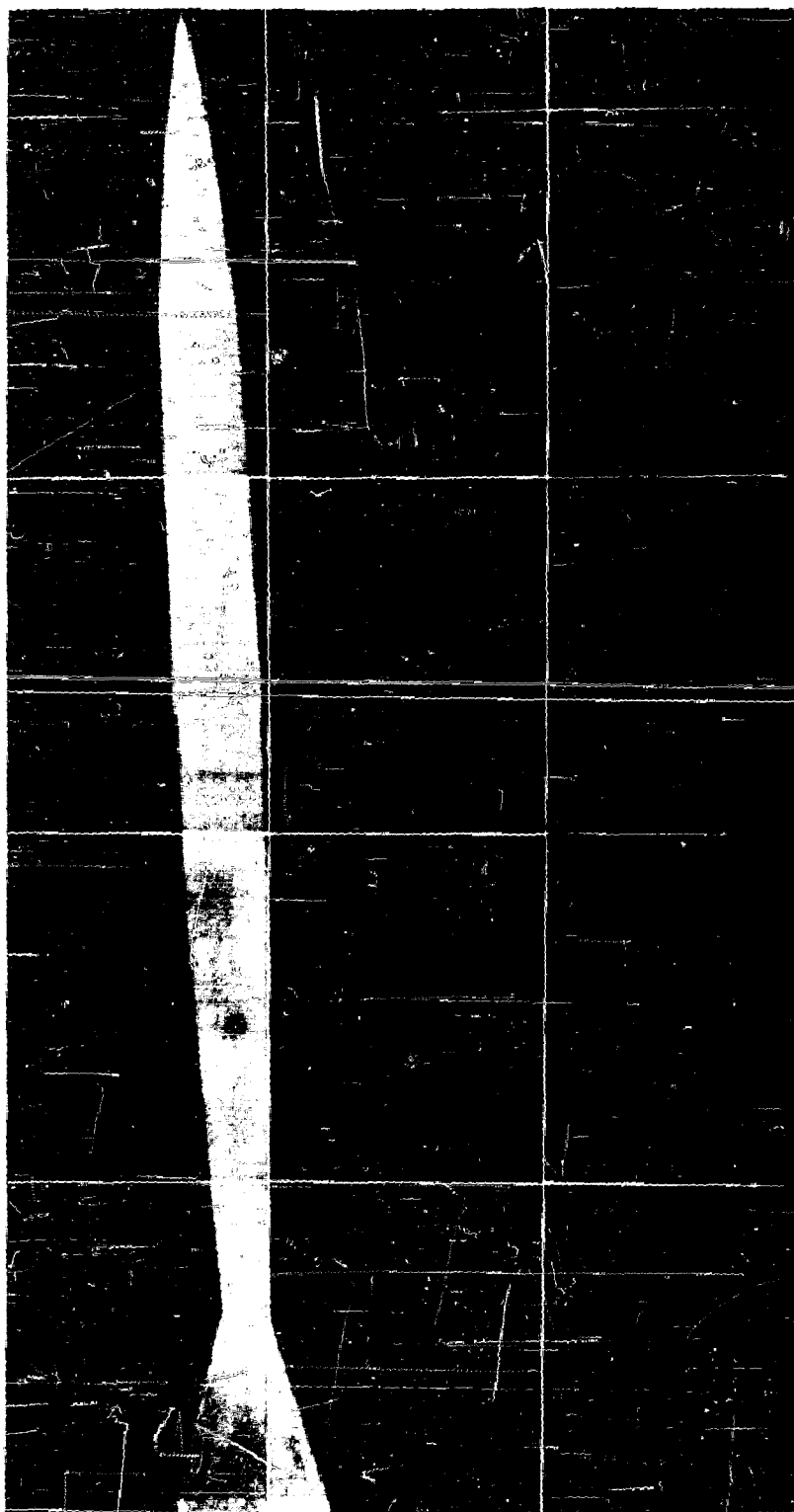


FIG. 3 HOLOGRAPHIC SHADOWGRAPH OF SECOND GENERATION GUN PROBE

TABLE I  
PHYSICAL AND AERODYNAMIC PROPERTIES OF PROBE

W	20.35	Weight (lbs.)
$I_y$	1947.4	Transverse moment. of inertia (lb.-in. <sup>2</sup> )
CM	24.86	Center of mass (in. from base)
d	2.629	Diameter (in.)
M	4.4	Mach number
$\sqrt{\frac{\sigma}{\rho}}$	3.3	Mean-squared yaw (degrees)
$C_D$	0.194	Drag coefficient
$C_{M_\alpha}$	- 6.1	Static moment coefficient
$C_{N_\alpha}$	4.4	Normal force coefficient
$CP_N$	21.22	Center of pressure (in. from base)
$C_{M_q} + C_{M_{\dot{\alpha}}}$	- 450	Damping moment coefficient
$V_p$	16.5	Package volume (in. <sup>3</sup> )
$V_f$	7.1	Fuze volume (in. <sup>3</sup> )
	1500	Distance for initial angle to damp to half amplitude (ft.)

of the new probe was 0.17 at a Mach number of 4.4 (Fig. 9). This value is quite superior to that of 0.30 for the first generation probe at the same Mach number. With this drag coefficient, weights of 18.5 to 20.5 lbs. ( $W/C_D A$  at  $M = 4.4$  in the 2900 to 3200 lb/ft<sup>2</sup> class) and the higher muzzle velocity of 5500 ft/sec (made possible by an extension on the gun), trajectory calculations indicated that the second generation probe should be capable of reaching altitudes in excess of 200,000 ft. (Fig. 10).

#### B. Fuze and Package

After the June 1962 tests (results given in the next section) in which the projectiles had attained good altitudes and no functions were observed, a reinvestigation of the new fuze design (described in Section III) was carried out by the BRL. To simulate the gun launching loads, the fuze was placed in a carrier and fired backward, at low velocities (approx. 300 fps), into a lead block. This impact in the lead block simulated the direction, rise-time, and peak acceleration of a normal probe launch.

These tests indicated that for load levels above 40,000 g's, the two ball detents employed in the starter would become jammed (rise time to peak pressure was too fast) and would not permit the match stick to drop onto the anvil, thereby lighting the fuze cord.\* To overcome this unlocking problem, the detent was changed to a shear pin mechanism which proved to be more reliable. Other deficiencies appeared in further tests but were of a nature that should be cured by adequate manufacturing control.

The final lot of fuzes for the December 1962 tests was produced and five of the lot were tested by firing into lead. Four of the five operated acceptably, one prematured by functioning on impact. Although the premature type of failure is the most unacceptable, the "80%" success of the final lot seemed to give reasonable assurance of success.

A horizontal test of the full scale telemetry package (20 mw) was made at the Transonic Range prior to the December 1962 firing and gave good transmission after launch, indicating that it withstood the g loading.

\* Actually at above 50,000 g's, the striker could override the detent even if it jammed and would function anyway.



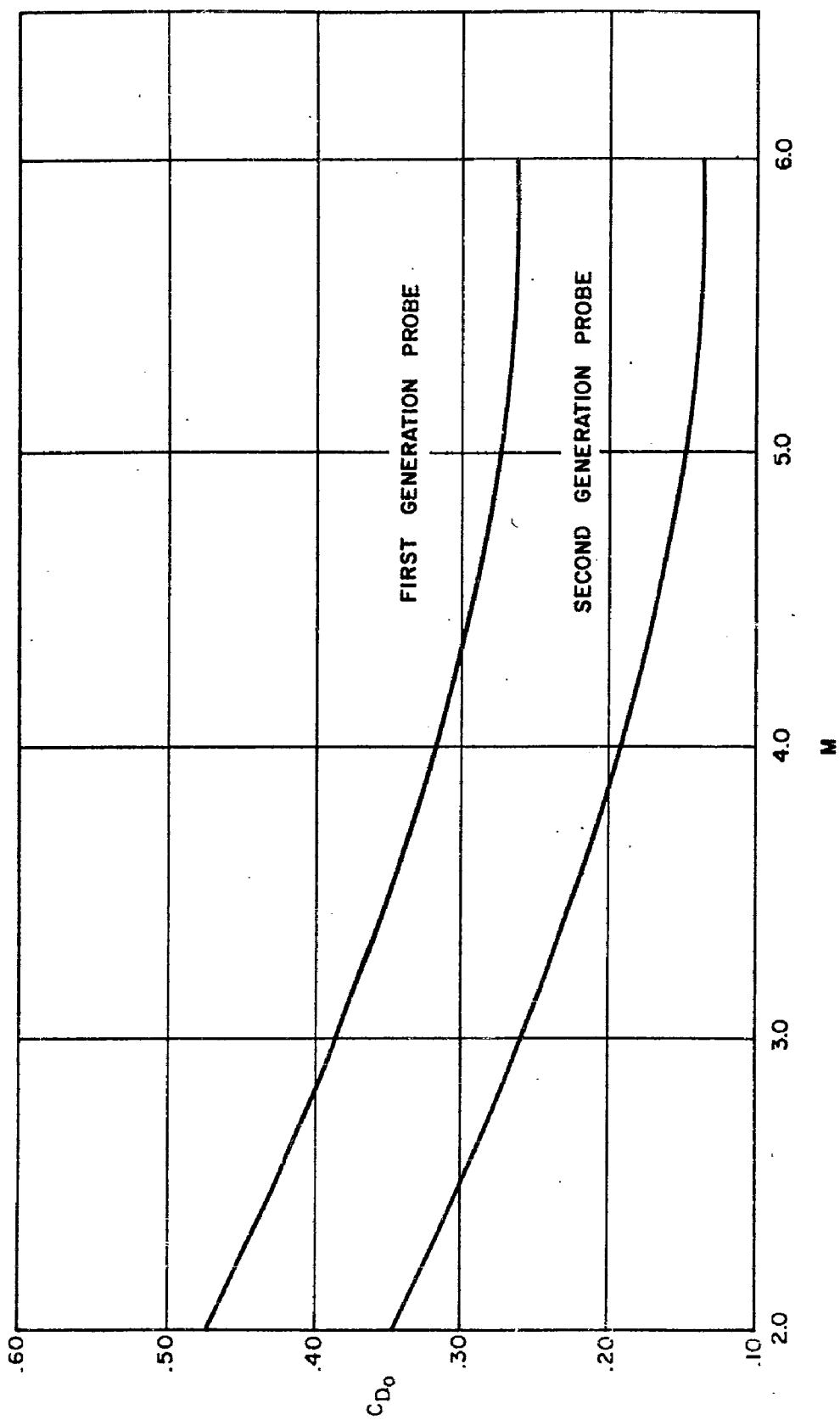


FIG. 9 ZERO-YAW DRAG COEFFICIENTS  
VS  
MACH NUMBER

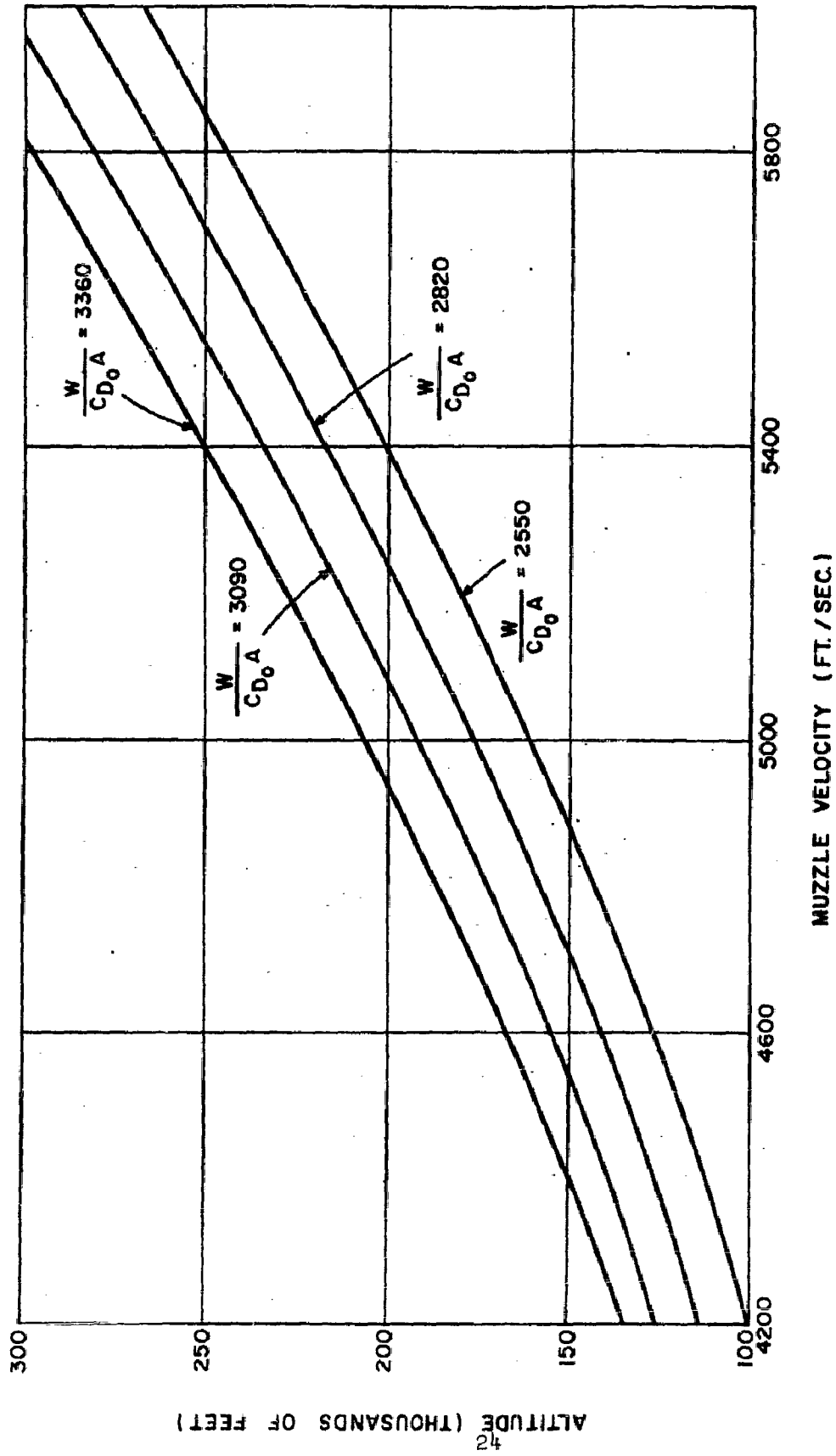


FIG. 10 - PREDICTED ALTITUDE

VS

MUZZLE VELOCITY AND  $\frac{W}{C_{D_0} A}$  (LBS./FT.<sup>2</sup>)  
M = 4.4

The Picatinny flash package (described in Section III) was tested\* in an altitude chamber at a pressure altitude of 100,000 ft. and yielded 375,000 ft. candle seconds. The flash unit was also fired into lead blocks at BRI, and was found to withstand 65,000 g's.

#### V. VERTICAL TESTS

The extended T123 tank gun was mounted on a 155mm M2 field carriage for the vertical phase of the 1962 test, and the gun carriage was again placed on an incline to increase the elevation angle to 90°.

The recorded data for the firings are given in Tables I and II. The first vertical test series, conducted in June 1962, was fired for altitude determination purposes. The firing sequence for this series included the firing of three spotting rounds, with impact charges, for programmed altitudes of 100,000, 150,000, and 200,000 ft. and these rounds were followed by the firing of three rounds with flash units to programmed altitudes of 230,000, 220,000, and 200,000 ft., respectively. The flash units were to be activated by ejection fuzes, and it was believed that photography would make altitude determinations possible.

The wind shields of the spotting rounds were weaker than those of the other rounds and were lost on those rounds programmed for 150,000 and 200,000 ft. Two of the flash rounds reached altitudes between 240,000 and 250,000 ft., according to estimates based on elapsed time of flight, but no functions were observed. The third flash round had a very short time of flight and it seems probable that it functioned on launch.

The second vertical test series, conducted in December 1962, was fired both for altitude determination and instrument package tests. The firing sequence for this series began with the firing of a spotting round for a programmed altitude of 90,000 ft. This round was followed by the firing of two rounds with "on-board" telemetry packages for initially programmed altitudes of 135,000 and 145,000 ft., and these rounds were followed by a chaff round, a telemeter round and another chaff round to altitudes of 225,000, 175,000, and 230,000 ft. Three flash rounds were then fired for programmed altitudes of 195,000, 200,000, and 200,000 ft., respectively.

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\* at Picatinny Arsenal

TABLE II  
VERTICAL FIRING DATA

Type Round	Time of Firing	Sabot Diameter (inches)	*Flight Weight (lbs)	Chamber Pressure psi (true)	**Muzzle Velocity (ft/sec)	Programmed Altitude (ft)	***Attained Altitude (ft)
<u>7-8 June 1962</u>							
1 Spotter	1727	5.107	18.6	24,600	4,000	100,000	65,000
2 Spotter	2013	5.107	18.6	46,300	5,200	150,000	(a) 40,000
3 Spotter	2052	5.107	18.6	63,600	5,600	200,000	(b) 40,000
4 Flash	2147	5.107	19.5	59,200	5,400	230,000	(c) 250,000
5 Flash	2350	5.107	19.5	57,500	5,350	220,000	240,000
6 Flash	0028	5.108	19.5	59,600	5,400	200,000	(d) 40,000
<u>3-4 December 1962</u>							
1 Spotter	1604	5.116	18.6	21,600	3,800	90,000	95,000
2 Telemetry	1650	5.116	19.2	38,600	4,450	135,000	155,000
3 Telemetry	1742	5.116	19.2	40,200	4,550	145,000	120,000
4 Chaff	1858	5.117	19.8	60,000	5,300	225,000	215,000
5 Telemetry	2043	5.118	19.2	47,300	4,900	175,000	150,000
6 Chaff	2129	5.120	19.8	58,800	5,400	230,000	210,000
7 Flash	2259	5.120	19.4	51,100	5,100	195,000	190,000
8 Flash	0041	5.120	19.4	52,800	5,150	200,000	(e) 50,000
9 Flash	0221	5.121	19.4	53,000	5,150	200,000	140,000

\* Add 5.20 lbs. sabot weight for launch.

\*\* Determined from pressure measurements.

\*\*\* Determined from flight times.

(a) Spotting nose failed during launch.

(b) Spotting nose failed during launch.

(c) Altitude is in excess of 250,000 ft. Due to abnormal flight time some observers had given up on round, and quoted times are from only two observers.

(d) Premature function of ejection system.

(e) Premature function of ejection system.

TABLE III  
VERTICAL FIRING DATA  
Flight times (seconds) observed by sound

I  
Field  
Worton  
Point  
Iago  
Point  
Range  
Central

Gun  
Position  
Approximate  
Flight  
Time

Type  
Round  
W/C D<sub>0</sub>  
(lb/ft<sup>2</sup>)

7-8 June 1962

3-4 December 1962

128  
90  
90  
283  
265  
90

174  
224  
194  
248  
215  
238  
217  
111  
192

156  
197  
180  
271  
207  
239  
238  
111  
201

166  
215  
183  
227  
197  
243  
231  
111  
191

174  
222  
193  
244  
242  
235

167  
220  
194  
246  
206  
240  
228  
111  
191

155  
199  
174  
233  
195  
229  
220  
105  
186

2,900  
3,000  
3,000  
3,090  
3,000  
3,090  
3,030  
3,030  
3,030

Spotter  
Telemetry  
Telemetry  
Chaff  
Telemetry  
Chaff  
Flash  
Flash  
Flash

1 2 3 4 5 6 7 8 9

Spotter  
Spotter  
Spotter  
Flash  
Flash  
Flash

1 2 3 4 5 6

During the firing program, all rounds except the next to last flash round appeared to behave normally with respect to making altitude. The next to last flash round behaved in a manner that indicates it functioned on launch. The highest powered telemetry model and two meteorite rounds were not fired; the former because it could not be turned on just prior to loading, the latter two because there seemed to be fuze functioning difficulties in the test series up to that point.

The 20-mw telemetry probe tested in the horizontal firings was just barely adequate for the vertical tests, particularly since the power level could not be determined before assembly and had ranged from 10-20 mw. After the horizontal tests, minor revisions permitted the battery power to be increased, yielding up to 100 mw of output on initial tests. These higher power units, however, exhibited a very undesirable characteristic. For some unknown reason, the emitted power decayed with time after potting and, even worse, the rate of decay was not constant but increased sharply with time. As a result, although a few days before the firing it was anticipated that power levels of 40 mw would be obtained, in actuality, all units showed very low power during pre-launch check-out tests (7 mw, 10 mw, and 10 mw, respectively). In fact, the telemetry unit which performed successfully at the Transonic Range had twice the power of the units available for the vertical test. Since the probe antennas were essentially dipoles with a deep null off the tail, it was necessary to locate the receiving station some distance from the launch site so that the receiver did not look at the antenna null. The receiving station, therefore, was located at Spesutie Island fourteen miles from the launch site. This station was not able to confirm reception of signals from any of the firings. A receiver was located at the gun for the last firing, however, and did receive a signal.

The two flash rounds which reached altitude were not observed to function. The Nike radar units were not available for tracking during the December 1962 firings and, therefore, an M33 radar, operated by Development and Proof Services, was employed for the two chaff rounds. Although the probes reached programmed altitudes, there was no sighting of chaff. Four possibilities exist; the chaff was not ejected, the chaff ejected properly but was missed by the tracking station, the chaff ejected but failed to spread, or the chaff

was expelled so far from the programmed time that it was missed in the search. Since the elapsed flight times indicated that the probes reached the programmed altitudes, it can be presumed that at least they did not function early in flight. An early function would cause an increase in drag and, hence, a short time of flight.

## VI. DISPERSION OF SYSTEM

The major results of the probe firings are demonstrated in the accuracy and altitude capabilities of the gun probe system. Altitudes of about 250,000 feet were achieved and all intact rounds were contained within a circle of 1600 yards radius.

In the June firings, the desired point of impact was about 4000 yards from Lego point along a bearing of  $285^{\circ}$  (clockwise from south) (Fig. 11). The desired impact was not changed during the firings and therefore the impact points can be plotted directly. In these firings, three of the probes were damaged at launch. These rounds impacted approximately 3000 yards from the launch point. The three intact probes impacted within a 3000-yard radius circle of the target point. From these results, it is seen that the danger area is roughly shaped like an ice cream cone. It is necessary, however, to add a 2000-yard radius circle around the gun, for sabot and gas seal parts which are released at launch. It can be seen that even with damaged projectiles (and wind allowances of over 1000 yards) the rounds impacted in a well defined area.

During the December firings, the proof officer had to exercise a very positive control over the impact point, in order to be permitted to continue firing. The firings were started on December 3 with a desired impact point on an azimuth of  $285^{\circ}$  and mid-way between the ship channel and Lego point. Based on wind data taken from a balloon flight six hours before firing, a 1200-yard wind allowance was made for the first round and it impacted on water short of the target point (Fig. 12). To get a better feeling for wind conditions aloft, round 2 was deliberately fired long. This proved to be a desirable impact area and round 3 was dropped near by. After round 3, a low fog settled in the danger area and made it impossible to identify boats in the ship channel. This situation necessitated dropping the rounds into an inner target area or a cease fire. As a result, the proof officer attempted to

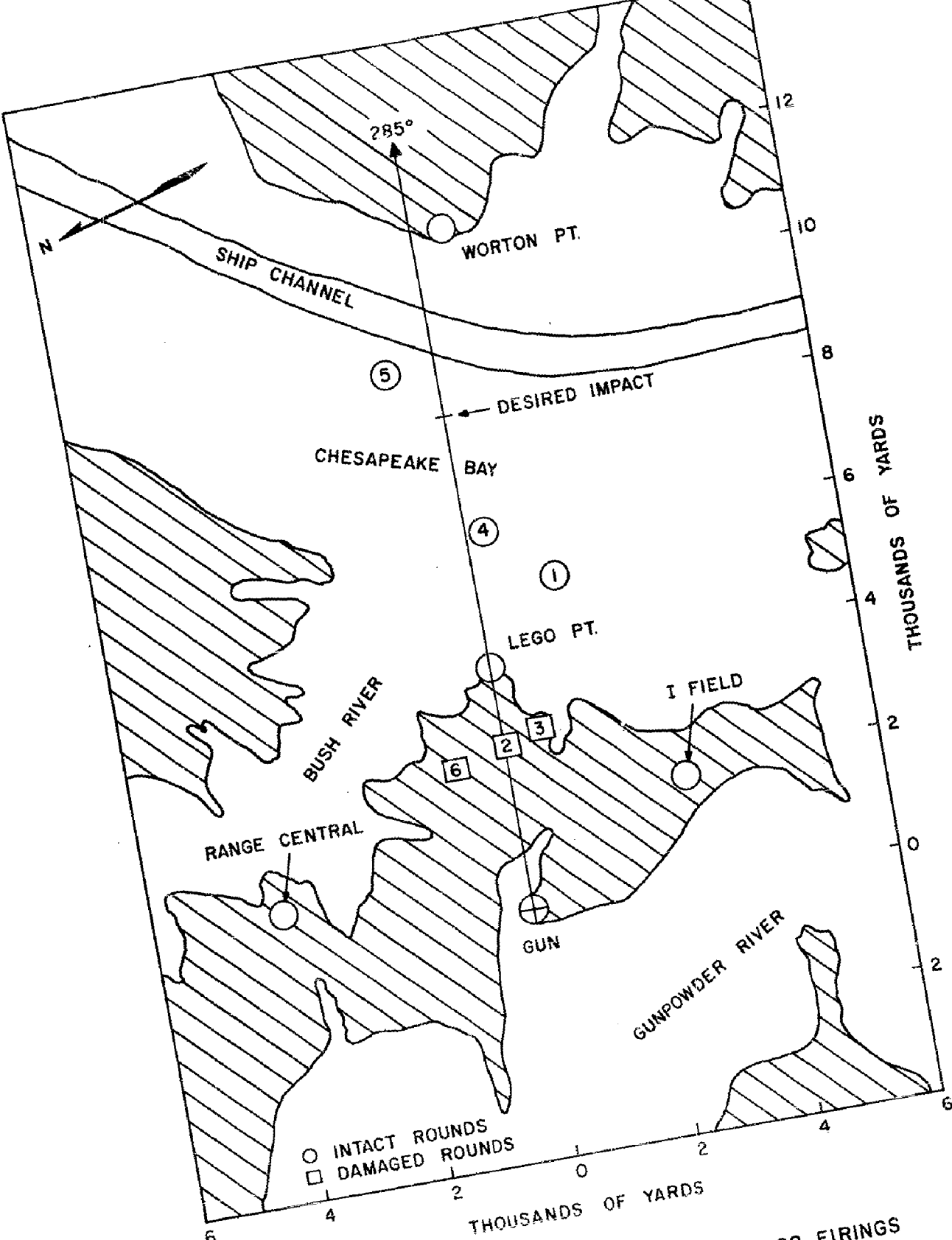


FIG. 11 - ROUND IMPACT AREA, JUNE 1962 FIRINGS



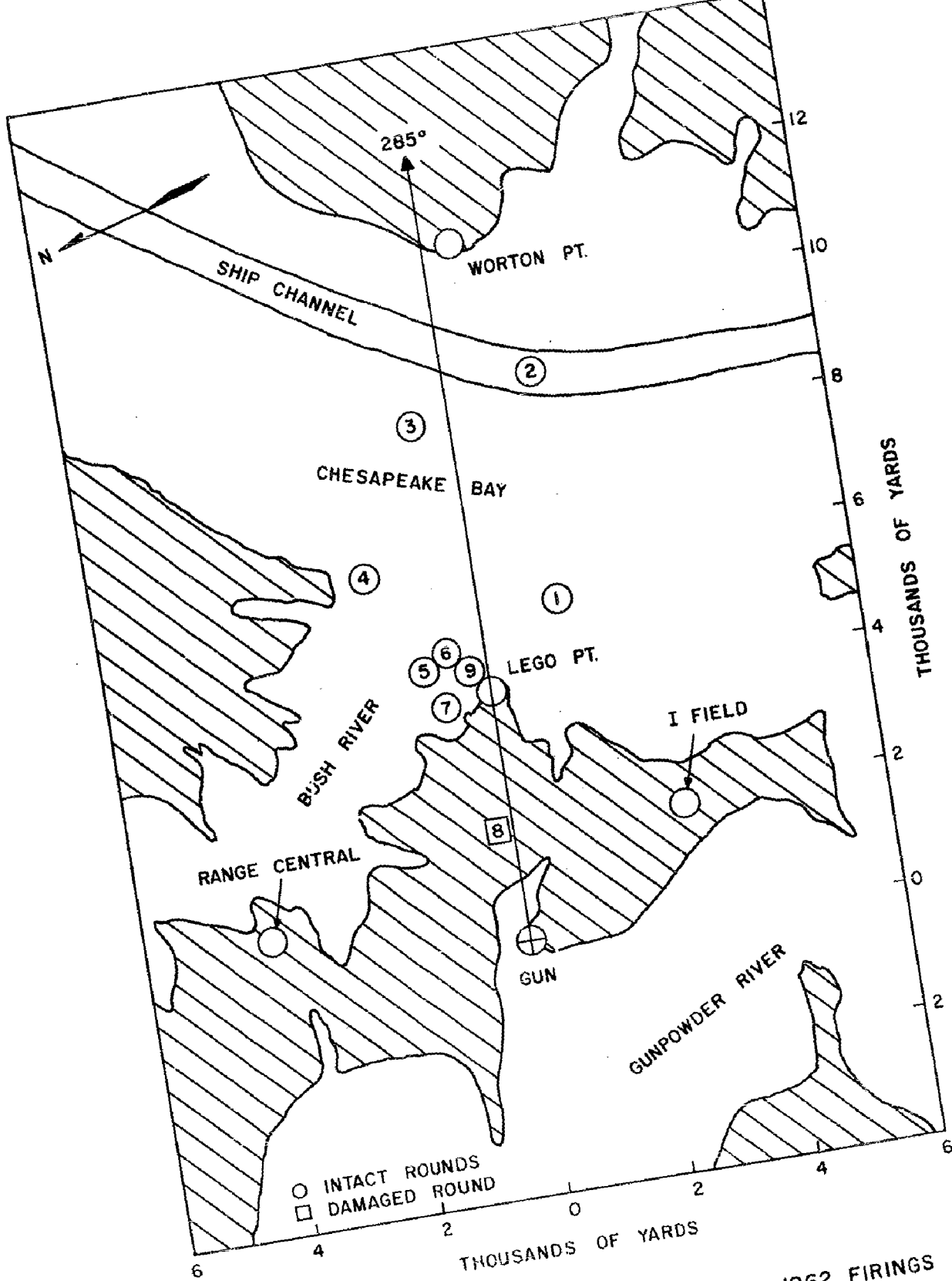


FIG. 12 - ROUND IMPACT AREA, DECEMBER 1962 FIRINGS

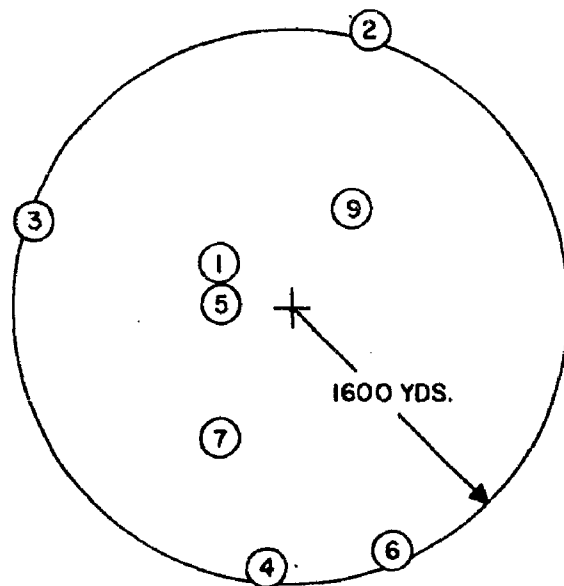


FIG. 13 - DISPERSION FOR DECEMBER 1962 FIRINGS

place round 4 in the mouth of Bush River. This was done and as the fog conditions worsened, the rounds were dropped toward the shore of Lego point. Except for round 8, which functioned early, all rounds fell quite close to the point predicted by the proof officer prior to launch. Since major changes in the desired point of impact were made several times, the plotted impacts of Figure 12 cannot be directly used to construct a dispersion pattern.

Predicted impact points were computed for each round,<sup>11</sup> except round 8, and the dispersion pattern with respect to these points is given in Fig. 13. A circle of 1600 yards radius encompasses all the rounds. All impact locations were sound ranged only, since no actual impacts were sighted by the observers. The ability to maintain control and have adequate "observation" of the impact, from the safety point of view, under adverse conditions, seemed better than would have been hoped for.

It might be noted that this impact circle of 1600 yards radius is achieved after a total flight of 100 miles. This result roughly corresponds to placing all rounds into Central Park, New York, when launching from Philadelphia.

## VII. SUMMARY

1. As a result of two series of firings in 1962, the capability of a 5-inch gun to launch a fin-stabilized, low drag probe to altitudes of at least 240,000 ft. has been demonstrated.

2. Dispersion of probes which did not structurally fail was less than one mile in radius. The total ground impact area required for sabot fragments, shorts and good rounds was a rectangle with sides of four and ten miles.

3. The performance of payload packages was disappointing; however, there is no reason to believe that successful performance of the chaff, telemetry and flash packages cannot be obtained during the next firing series.

4. The highly mobile 5-inch gun probe system has demonstrated excellent capability to reach high into the upper atmosphere. The low dispersion of the system makes upper atmosphere measurements possible in many parts of the United States for which rocket firings are not feasible; although, some care is required to avoid the possibility of blast damage due to focusing effects.<sup>12,13</sup>

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